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ICT Diffusion at Developing Countries: The Role of Governance Types and Mechanisms

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ABSTRACT

The diffusion process of information and communication technology for mobile telephones, personal computers and internet users seems to follow the Bass' diffusion model in most nations, but some of the factors affecting diffusion speeds are still unidentified. We focused on three geographical regions, of mostly developing nations namely: Eastern Europe, Southeast Asia, and Central America/Caribbean to compare diffusion speeds. We included economic wealth, social infrastructures, and governance mechanisms to measure their impact in the diffusion speed for a period of 20 years.

Based on secondary data, we conclude that geographical location, financial status, social infrastructure and governance mechanisms impact diffusion speed of three ICT products (PC, mobile phones and Internet). Along with the economies, we discovered that the types of government (democratic, autocratic and communist), follow the same diffusion shape, but the speed of diffusion is greatly altered by governmental intrusion in this matter. Governance mechanisms also affect diffusion speed.

Keywords

Diffusion, Bass, secondary data, government, clustering.

INTRODUCTION

By the end of 2008, 4 billion people around the world were using mobile phones (ITU, 2008). Launched in 1981 in Scandinavia, mobile phone service has become a part of everyday life for more than half of the world's population residing in 211 countries. Moreover, in several developed nations, the mobile phone has reached a penetration level that some countries like Panama have more than 100 phones per 100 inhabitants according to the numbers published by the World Bank. This represents that consumers have more than one phone, more than one phone number, more than one time card, and/or more than one provider.

The period between the early 1990s can be regarded as the turning point in the telecommunication industry with the opening of a traditionally closed and de facto monopolistic, even in some cases government controlled market into a competitive one. This market liberalization movement has been forcing telecommunications industry and governments to shift from measuring production costs to the assessment of productivity. Some governments have been forced to develop or liberalize norms and policies for the information and communication technologies (ICT) sectors, so that they can invest large portions of their budgets in ICT.

What some countries are missing is a clear path to follow. The International Telecommunication Union (ITU) has pointed out that there is still very little research measuring the impact of ICT expansion in developing countries (ITU, 2008). Therefore, they emphasize the need for government policy makers to evaluate ICT performance at the sector and national levels by improving policies.

While studies at national level have explored diffusion of ICT products, studies on regional clusters of nations or governmental differences resulting in differences in regulations on the same topic are scarce (Peres, Muller & Mahajan, 2010). Multi-national diffusion model-based studies of innovation exist; however, diffusion of innovation in developing world is also a future area of research, according to the same authors. The present article tries to fill up these gaps in these research areas.

In particular, the present paper studies the differences in three sets of developing/emerging nations. Nations can be grouped/ clustered in terms of physical distance (regional clusters, as in the present case), economic distance (such as developing and developed nations), cultural distance, regulatory differences for example. In this paper we are going to group countries that are mostly developing and implementing ICT in the world regions as shown in table 1.

Southeast Asia SA	**Eastern Europe EE**	**Central America/Caribbean CC**
Brunei	Belarus	Belize
Cambodia-	Bulgaria	Costa Rica
Lao-	Czech+	Cuba
Indonesia	Hungary+	Dominican Rep.
Malaysia+	Moldova	El Salvador
Myanmar-	Poland+	Guatemala
Philippines+	Romania	Haiti-
Singapore+	Russia	Honduras
Thailand+	Slovakia+	Nicaragua
Viet Nam	Ukraine	Panama

Table 1 – Country Clustering

We did a simple clustering of nations by grouping the nations based on physical proximity. Thus all nations within the Eastern Europe (EE), Southeast Asia (SA), and Central American/Caribbean (CC) nations were classified in three separate groups; these countries are developing economies and even though they are distant from each other in some respects, they are similar in many other respects. Peres et al., (2010) also points out that there is little research so far that relates the degree of clustering in a given social network to the speed of diffusion of an innovation (or coefficient of diffusion) within that network. Goldenberg et al. (2001), Shaikh et al. (2006) studied various aspects of this but not the relations between clustering and the speed of diffusion.

In this paper we consider Van den Bulte's (2002) definition of diffusion speed as the speed at which new products get adopted and diffuse through the market. We are going to investigate the relation between speed of diffusion and strong clustering as could be introduced by physical proximity and other similar aspects of these nations, due to "spill-over effect" introduced by diffusion in neighboring nations (Ganesh et al., 1997).

Based on the World Bank classification most countries in this list are developing, although some countries such as: Malaysia, Philippines, Singapore, Thailand, Czech Republic, Hungary, Poland and Slovakia have graduated as developed economies as recently as 2012 (denoted by "+" sign in Table 1). In this classification, there is also a word of caution about some countries that are named as the least developing countries, such as Cambodia, Haiti, Laos and Myanmar (shown as "-" sign in Table 1). Also, there is no other information about Cuba except that it is a communist nation.

Another factor to consider in this study is related to governmental differences which are a horizontal social influence. Social signals contain information regarding the social consequences of adopting the product, including the social risk of adopting the innovation. Social signals are transmitted horizontally to indicate group identity (here a nation). Adoption of an innovation by people in a given group signals to members of that group to adopt and to members of other groups who want to differentiate to avoid adoption (Berger & Heath, 2008). Government type of a nation introduces different regulatory differences and issues such as regulation (Stremersch & Lemmens, 2009, Peres et al., 2010) are important as social signals can be influenced by regulations.

Similarly, one facet of governance is governance mechanisms introduced by a democratic government which may vary considerably than those introduced by a communist/autocratic regime. Regulation is a part of such governance mechanism. Kaufmann's indices on governance (2007) based on overall governmental regulation qualities vary a lot among different types of government; these scores are under the umbrella of the Worldwide Governance Index (WGI) which is available at the World Bank database. For example, the 2010 scores of regulation quality of one nation from each group can be compared. The values are from -2.5 (lowest quality) to 2.5 (highest quality). For Cambodia from SA cluster it was -.476, for Bulgaria from EE cluster it was .607 and for Costa Rica from CC cluster it was .506. This can be contrasted with Finland, a developed nation which had a value of 1.837.

The primary questions this study is attempting to address are: How does the speed at which mobile and PC lines are being adopted and diffused through the market vary across developing countries and products? And what are the embedded factors within the economies that have an impact on the diffusion on the ICT in question? The objective of the paper is to analyze the impact of social infrastructures, and institutional policies on the ICT sector in Eastern Europe, Southeast Asia, and Central American/Caribbean economies. Numerous similarities, such as ICT development level, same investment patterns, and similar policy-making measures and physical proximity make these countries interesting samples for this kind of study. We examined the ICT sector data of these countries over a 30-year period (1980–2010) using public secondary data from the World Bank Development Indicators, CIA, and United Nations Statistics Databases. The timeframe of our study is significant and it covers the period of world flourishing in ICT infrastructure at these countries.

DIFFUSION MODEL

As noted by Peres, Muller and Mahajan (2010), traditionally, the main thread of diffusion models has been based on the framework developed by Bass and so we adopt the Bass model in the present research. We begin this section with the representation of the Bass model for a single series. We adopt the definition of Peres et al (2010) of diffusion. They define it as "Innovation diffusion is the process of the market penetration of new products and services, which is driven by social influences. Such influences include all of the interdependencies among consumers that affect various market players with or without their explicit knowledge." Using the extension of the basic diffusion model (Bass, 1969) a non-linear solution is implemented. Boswijk and Franses (2005) borrow from financial econometrics a modified stochastic error process for the Bass model. Their approach is designed to capture heteroscedasticity errors and a tendency for the data to revert to the long-term trend. Additionally, this model includes an additional regressor and it is that we rely on simulated maximum likelihood to estimate the parameters.

The first developed Bass model states that the probability that an individual will adopt the innovation — given that the individual has not yet adopted it—is linear with respect to the number of previous adopters. The model parameters p, q, and m can be estimated from the actual adoption data. Here *p* is the innovation parameter, *q* is the imitation parameter, and *m* is the maturity or saturation level.

Following the representation as advocated in Boswijk and Franses (2005), we discuss the multi-level model for a panel of diffusion time series of ICT products. Finally, we report the parameter estimation of this last model.

The Bass model assumes a population of m potential adopters, where, in the context of citations, we will associate m with the maturity level. In our context, adopters should be viewed as articles which cite the articles under scrutiny. The maturity level can be viewed as the saturation when the total number of users is achieved. For each adopter, the time to adoption is a random variable with a distribution function F(t) and density f(t), such that the hazard rate equals

$$\frac{f(t)}{1 - F(t)} = p + q\,F(t) \qquad (1)$$

where p and q are the parameters that determine the shape of the diffusion process. The cumulative number of adopters at time t, denoted by N(t), is a random variable with mean

$$\bar{N}(t) = E\,[\,N(t)\,] = m\,F(t) \qquad (2)$$

where t is measured in continuous time and E denotes the expectation operator. It can be shown that the function $\bar{n}(t)$ obeys the following differential equation, that is,

$$\bar{n}(t) = \frac{d\bar{N}(t)}{dt} = p[\,m - \bar{N}(t)] + \frac{q}{m}\bar{N}(t)\,[\,m - \bar{N}(t)] \qquad (3)$$

According to Boswijk and Franses (2005), the solution of this differential equation is given by:

$$\bar{N}(t) = m\,F(t) = m\left(\frac{1 - e^{-(p+q)t}}{1+(q/p)e^{-(p+q)t}}\right) \qquad (4)$$

Note that these parameters p, q and m exercise a non-linear impact on the pattern of $\bar{N}(t)$ and $\bar{n}(t)$. Basic characteristics of the diffusion are also non-linearly dependent on *p* and *q*. These parameters provide us with speed of diffusion data. According to Van den Bulte (2002) a high p value shows that the diffusion has a quick start but it will go down quickly while a high q value shows that the diffusion is slow at first but it will accelerate afterwards. We are going to calculate *p*, *q* and *m*, but our main index is going to be the diffusion speed defined as the ratio of q/p. It is important to notice that if p is almost zero, the ratio will tend to infinite, so we are going to use natural log of *q/p*.

HYPOTHESES

In a meta-analysis of "diffusion speed" research, Van den Bulte (2004) uncovered interesting evidence about diffusion speed; this provides product managers and developers a useful quantitative tool to measure diffusion at certain product categories and regions of the world. According to Van den Bulte (2004), economic differences explain national variations in speed better than cultural differences do.

Scholars have studied the influences of many macroeconomic variables, yielding two main empirical generalizations: First, the wealth of the country (usually measured by gross domestic product (GDP) per capita), and also lead-lag effect, lifestyle, health status, and urbanization has a positive influence on diffusion (Peres et al., 2010; Desiraju, Nair, & Chintagunta, 2004; Talukdar, Sudhir & Ainslie, 2002).

Innovator and leading countries that have the same penetration rate for mobile phones and do not follow the expected S-pattern of diffusion, follow a different diffusion pattern (Wenrong, Xie, and Tsui, 2006), but in this paper we also want to find out (as a side interest) if these late innovator developing countries follow the expected S-pattern of diffusion or not.

With regards to internet users, researchers have found that although the pace of Internet adoption largely depends on a number of factors inside as well as outside the country, the results reveal some common pattern in introduction and diffusion of the Internet in various countries. Based in the innovation curve, the expected first users of the Internet are usually researchers and academics. However, the growth that follows innovators on the Internet adoption has moved faster at those countries where there is a commercial push - the emergence of commercial ISPs (Ang & Loh, 1996).

The present study shows that countries adopting technology later in the game have certain advantages because earlier adopters have discovered and solved set-up issues. This study does not include innovator countries but those that have not been early adopters of ICT; for instance, Eastern Europe countries are part of the European Union, and inside the EU many developed countries have already carried the burdens of improving and accumulating global critical mass (Rouvinen, 2006).

H1: The diffusion speed q/p of EE will be significantly greater than those from other regions of the world for they are geographically closer to countries that are economically strong and early adopters of ICT.

Understanding cross-country influences is valuable in the context of normative managerial decisions for multinational markets. Some studies have explored entry strategies — i.e., the question of whether a firm should enter all of its markets simultaneously (a "sprinkler" strategy) or sequentially. Kalish, Mahajan and Muller (1995) built a game-theoretic model for two brands and suggested that the waterfall strategy is preferable when conditions in foreign markets are unfavorable (slow growth or low innovativeness), competitive pressure is low, the lead-lag effect is high, and fixed entry costs are high.

Libai, Muller & Peres (2005) extended this question to explore responsive budgeting strategies in which firms dynamically allocate their marketing efforts according to developments in the market. Many other questions are still waiting to be answered and issues such as regulation (Stremersch & Lemmens, 2009), international competition, and the optimal marketing mix of growing international markets can be further explored.

The political type of government may matter. Thus an autocratic government may have a different policy than a democratic government or a communist government. According to Olson "whenever an autocrat expects a brief tenure, it pays him to confiscate those assets whose tax yield over his tenure is less than their total value. This incentive plus the inherent uncertainty of succession in dictatorships imply that autocracies will rarely have good economic performance for more than a generation." (Olson, 1993).

Looking at the possibilities of autocracies, we find communism lacks the self-renewing capacity that is found in democratic elections, therefore autocratic governments might not support ICT diffusion as communication media, for it could be seen as a tool to overthrow the government. This fear might be based on their ignorance about what the people think about them; mostly by fear of consequences (Wintrobe, 2001). In the past experiences, the world has witnessed that until a government opens up and allows entry to competition, it isn't possible for private companies that have the means, on regards to capital and technology, to join the market and promote diffusion of new technology (Samarajiva, 2006).

H2a: The diffusion speed (q/p) from Democratic countries will be significantly greater than those from other governments of the world for they allow entry of the private sector into ICT diffusion.

Governance Mechanisms and regulation

Governance mechanisms including regulation may play a significant role in diffusion speed of ICT products (Stremersch & Lemmens, 2009). In context of pharmaceutical industries they find that differences in regulation substantially contribute to cross-country variation in sales. Thus regulatory control such as manufacturer price controls has a positive effect on drug sales. The other forms of regulation such as restrictions of physician prescription budgets and the prohibition of direct-to-consumer advertising tend to hurt sales. In this article we consider regulation in general through governance. Governance is defined as "the traditions and institutions by which authority in a country is exercised…. the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them, " (Kaufmann et al., 2007). It could be noted that regulation could be related to type of governance. A democratic government may allow a more relaxed and transparent regulations that favor ICT adoption whereas an autocratic government may be stricter in regulatory restrictions that may inhibit free trade and thus ICT diffusion.

H2c: The diffusion speed in nations with good governance will be significantly greater than those from other governments of the world for they allow flexible and transparent regulations that hels in ICT diffusion.

METHODOLOGY

For this study we are going to use secondary data sources from the United Nations, World Bank, CIA and other public databases. The available data sets used are shown in Table 2.

Information	Category	Comments	Source
Average GDP	GDP per capita, PPP (current international $)	Latest data for 2010	World Bank Database
Cell Phone Users	Mobile cellular subscriptions (per 100 people)	Data from 1984 to 2009	World Bank Database
PC's	Personal computers per 100 inhabitants	Data from 1990 to 2008	UN Data
Internet Users	Internet users (per 100 people)	Data from 1991 to 2009	UN Data
Type of government	The World Fact Book	Consultation in web site (2011)	CIA Home
Governance indicators	Rule of Law, Regulation Quality, Accountability, Corruption, Government Effectiveness	No comments	Kaufmann et al., 2007

Table 2 – Data sources

The first step of the process is to calculate the p, q and m diffusion speed using the Bass model and the differential solution proposed by Boswijk and Franses (equation 4). We use Excel Solver software to approximate the curves to non-linear distributions following Bass' diffusion model formula and once the values of these parameters are obtained, we calculate the ratio imitators (*q)* /innovators (*p)* of ICT diffusion for the hypotheses testing. Based on this ratio we statistically compare averages and standard deviations to determine if they are equal.

We operationalize governance through various dimensions of governance indicators (Kaufmann et al., 2007). These are: Rule of Law, Regulation Quality, Accountability, Corruption and Government Effectiveness. Finally, we are going to run a regression with this diffusion speed and use governance indicators to determine if we can predict the speed based on economic and governance characteristics of the countries.

RESULTS AND DISCUSSION

Following the representation as advocated in Boswijk and Franses (2005) the estimation of diffusion speeds for the nations is first calculated. Using the resulted diffusion speed for each nation we make the categorization on the countries included in our sample as geographically located (Eastern Europe, Southeast Asia & Central America/Caribbean) accordingly, this distinction is shown in table 1, such clustering was used to observe actual diffusion curve in each case and is shown in fig 1.

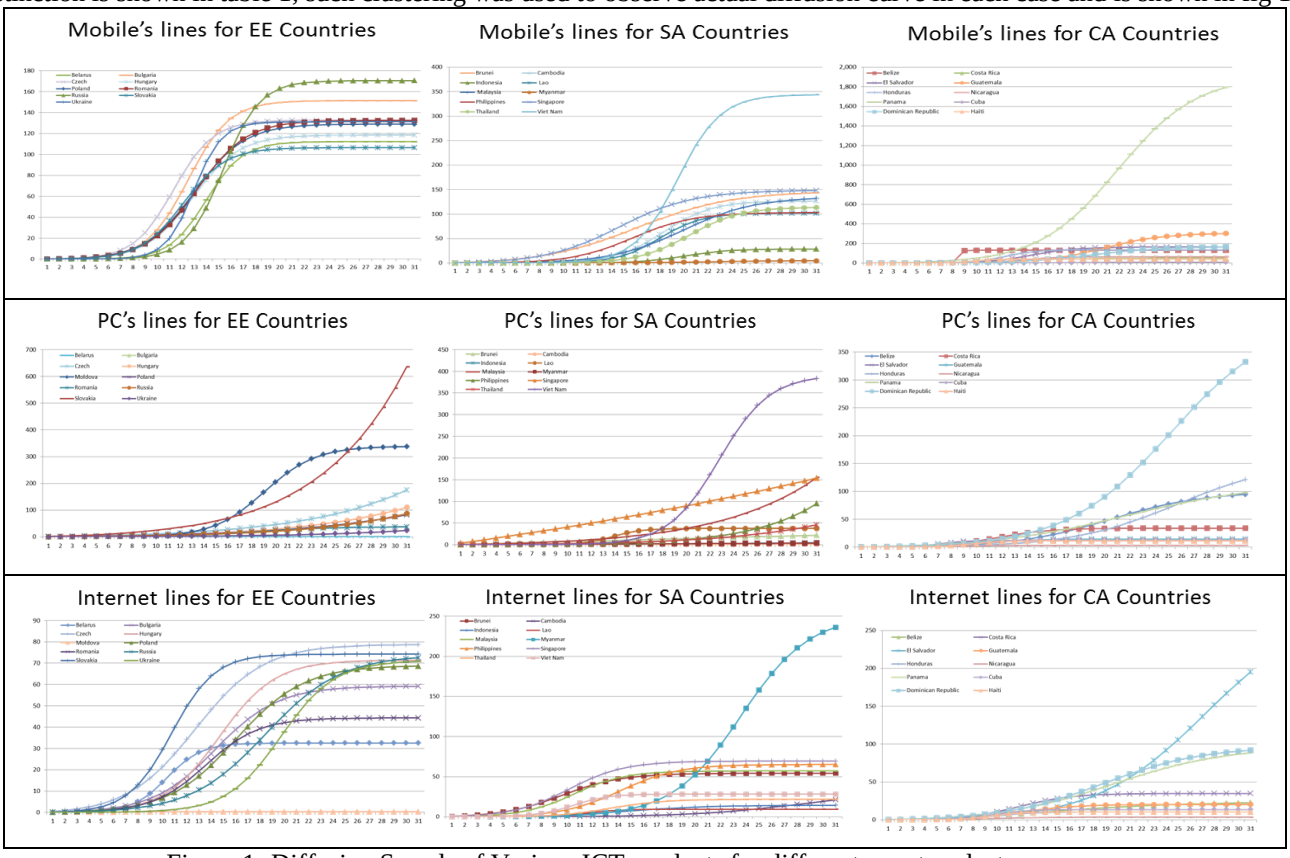

Figure 1- Diffusion Speeds of Various ICT products for different country clusters

Figure 1 shows the calculated diffusion curves following the shape described by Bass (1969), the x-axis represent the periods of the diffusion curves based on the available data. Most of the curves follow the expected diffusion curve with just a few exceptions that are showing different rates, for instance, the curve for mobile's line at Southeast Asian countries, Vietnam grew from 27 to 81 and 101 in just 2 years, this growth is due to the liberalization of the cell phone market in 2008. Another illustration of this behavior is present in Mobile's lines for Central American/Caribbean countries, where Panama had 164 cell phones per 100 people in 2009. Panama's 2010 census counted 3.4 million inhabitants but according to the mobile phone service, there were 6.5 million subscribers. The majority of cell phone users– an estimated 6.171 million – continue using prepaid cards versus the 324,808 users who subscribe to contracts with one of the telephone companies operating in the country (Garrido E.A., 2011).

Type of government	Country	Category	Type of government	Country	Category
Communist State	Cuba	Communist	Parliament Democracy	Belize	Democracy
	Lao			Bulgaria	
	Vietnam			Czech Republic	
Constitutional Democracy	Guatemala	Democracy		Hungary	
	Honduras			Slovak Republic	
	Panama		Parliament Republic	Singapore	Democracy
Constitutional Monarchy	Malaysia	Autocracy	Republic	El Salvador	Democracy
	Thailand			Haiti	
Constitutional Sultanate	Brunei Darussalam	Autocracy		Indonesia	
Democratic Republic	Costa Rica	Democracy		Moldova	
	Dominican Republic			Nicaragua	
Dictatorship	Belarus	Autocracy		Philippines	
Federation	Russian Federation	Democracy		Poland	
Militar regime	Myanmar	Autocracy		Romania	
Multiparty Democracy	Cambodia	Democracy		Ukraine	

Table 3 - Classification of Countries by Type of Government

When we test for the magnitude and direction on the coefficients of diffusion from EE and compared against the ones from other regions, we compare the mean on the diffusion speed. The results are shown in table 4.

		Cell Phones			P.C.s			Internet Users		
	N	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error
EE	10	13,500	27,579	8,721	352	396	125	0.0027	0.0032	0.0010
SA	10	15,482	20,535	6,494	135	157	50	0.0045	0.0055	0.0017
CC	10	6,687	7,950	2,514	71	105	33	0.0136	0.0211	0.0067
Total	30	11,890	20,030	3,657	186	273	50	0.0069	0.0132	0.0024

Table 4 – Innovators/Imitators ratio comparison for ICT

Figures 2-4 depict the information presented in Tables 4 and 5. The diffusion speeds for the three selected ICTs were different for all regions. There is no predominant region on regards to diffusion speeds, because the higher mobile phone diffusion speed come from SA, while personal computers diffusion speeds are higher for EE; and finally, the number of internet users' diffusion speed is higher for CC. We tested the magnitude and direction of diffusion speed from democratic governments' nations to determine if they were significantly greater than the ones from the autocratic ruling nations, as stated in hypothesis 2a. We compare the mean on the diffusion speed; the results are shown in Table 5.

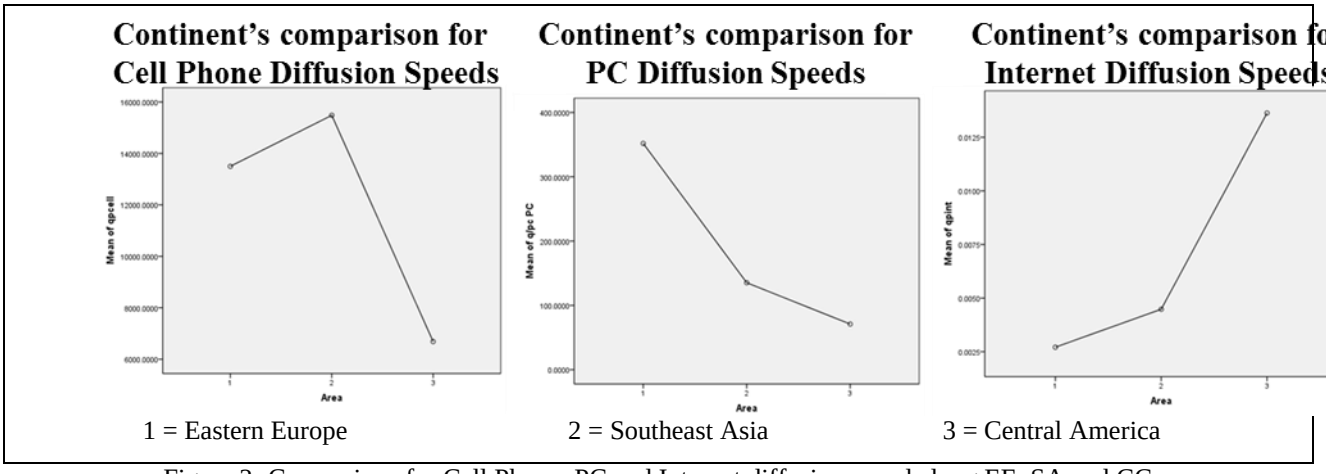

Figure 2- Comparison for Cell Phone, PC and Internet diffusion speed along EE, SA and CC

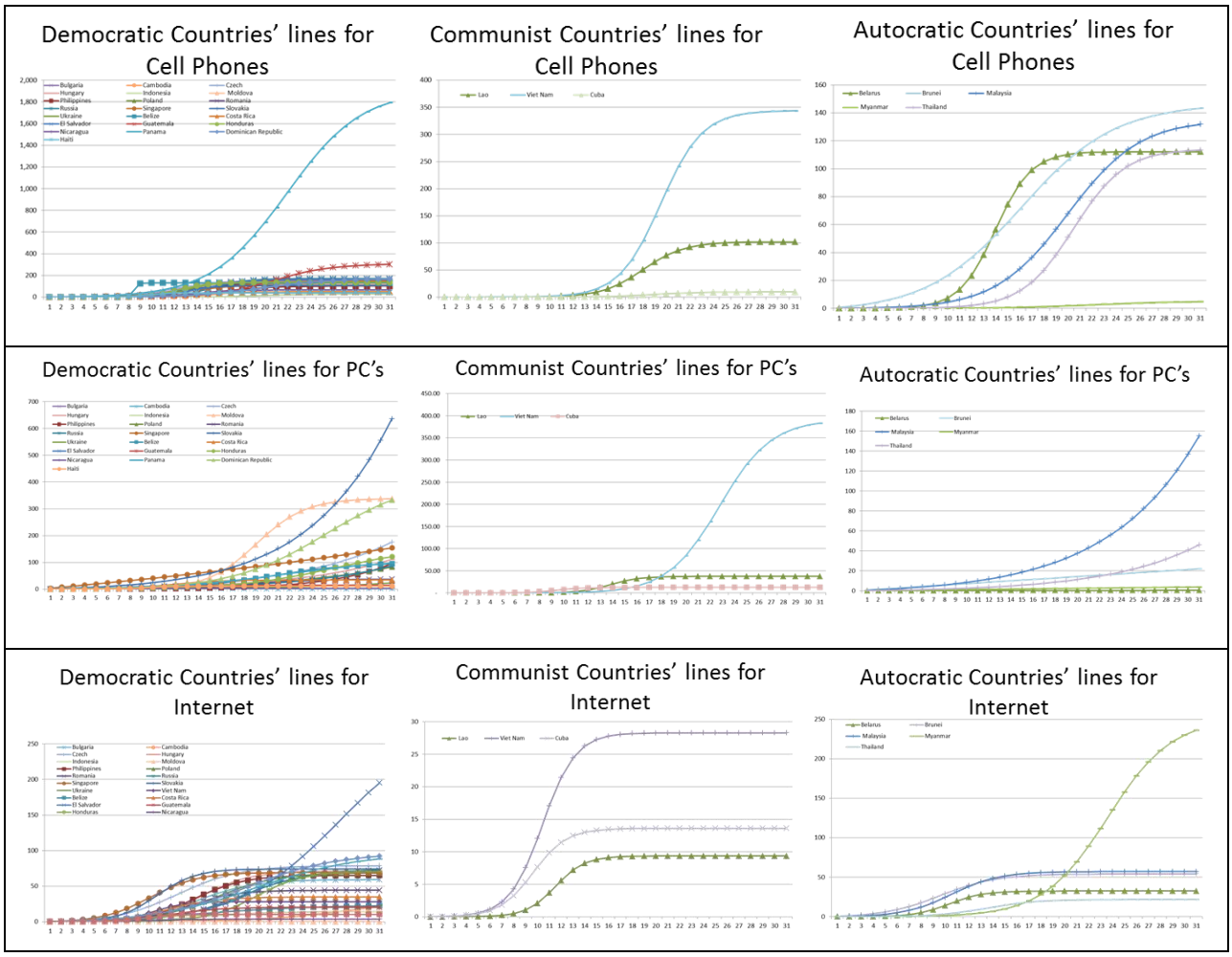

Figure 3- Diffusion for Cell Phone's, PC's and Internet lines curve among the different economic regimens

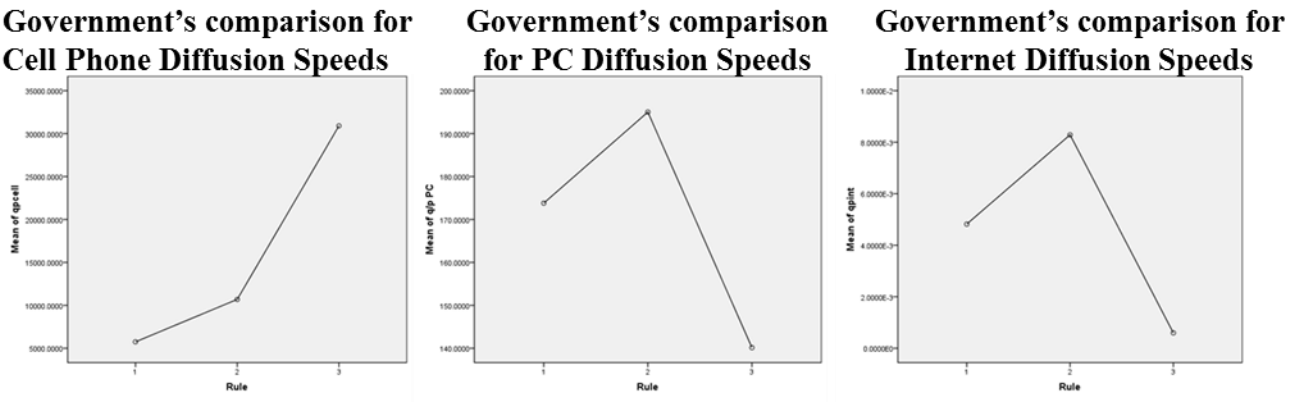

Figure 4 - Governments' Comparison of Cell Phones, PCs and Internet Diffusion Speeds

		Cell Phones			P.C.s			Internet Users		
	N	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error
Autocracy	5	5,749	7,302	3,266	174	165	74	0.0048	0.0070	0.0031
Democracy	22	10,694	20,629	4,398	195	307	66	0.0083	0.0149	0.0032
Communist	3	30,899	24,302	14,031	140	180	104	0.0006	0.0005	0.0003
Total	30	11,890	20,030	3,657	186	273	50	0.0069	0.0132	0.0024

Table 5 - Governments' Comparison of Cell Phones Diffusion Speeds

As the means were very different for the regions and types of governments, we conducted a t-test on every region compared to the rest of nations from other regions to determine if the means are statistically the same. The F from the independent samples t-test is shown in Table 6a. The results are mixed. CA diffusion speeds are different from others while EE is superior to others in PC diffusion rate only and SA is not different for none of the technologies considered. Thus H1 is only partly supported.

For testing H2a, the type of government was taken in consideration to analyze if this factor impacts diffusion speed. The diversity of government regiments was taken from the CIA database and it is summarized in the Table 3 No support can be found for H2a though from Table 6b.

	Cell phones		PC's		Internet users	
	F	Sig.	F	Sig.	F	Sig.
EE	1.258	0.272	15.789	0.000	2.976	0.096
SA	0.647	0.428	1.949	0.174	1.186	0.285
CA	4.672	0.039	6.31	0.018	7.684	0.010

Table 6a – t-test for regions

	Cell phones		PC's		Internet users	
	F	Sig.	F	Sig.	F	Sig.
Autocracy	1.829	0.187	0.481	0.494	0.244	0.625
Democracy	0.004	0.953	0.938	0.341	0.878	0.357
Communist	0.317	0.578	0.292	0.593	1.163	0.29

Table 6b – t-test for government types

For testing H2b, we created a new dependent variable that equals the natural log of the diffusion speed and used log of GDP and Kaufmanns governance indicators as independent variables. The significant results are shown in table 7:

ICT type	Independent Variable	B	Std. Error	Beta	B	Sig.	R Square
Internet	(Constant)	-6.767	0.454		-14.905	0.000	0.34
	GDP avg	0.209	0.083	0.419	2.508	0.019	
	Voice & Accountability	0.682	0.38	0.3	1.798	0.084	
PC	(Constant)	5.941	0.818		7.261	0.000	0.67
	GDP avg	0.25	0.135	0.38	1.859	0.076	
	Gov. Effectiveness	4.377	1.262	1.497	3.469	0.002	
	Control of corruption	-4.798	1.281	-1.484	-3.746	0.001	
	Regulatory Quality	-2.658	0.931	-0.905	-2.856	0.009	
	Rule of Law	3.331	1.416	1.037	2.352	0.028	
Mobile	(Constant)	8.664	0.433		20.002	0.000	0.46
	GDP avg	-0.276	0.079	-0.526	-3.483	0.002	
	Voice & Accountability	-0.718	0.362	-0.299	-1.983	0.058	

Table 7 - Analysis Results

For cell phones subscriptions per 100 inhabitants, we found that R^2 is 0.46. Doing the regression for the personal computers per 100 inhabitants, we found that the variables explain 67% of the variation of the dependent variable and the Internet regression shows an R^2 value of 0.34. For each of these regression N=29. Internet and Mobile results are opposite indicating that governance mechanisms work in opposite way on these ICT products. For PC, the results are mixed. Government effectiveness and Rule of law have a positive influence on PC diffusion speed, whereas control of corruption and regulatory quality has negative impacts on diffusion speed. Thus H2c is supported.

Preliminary results show H1 is supported for personal computers, but rejected for cell phones and internet users. The reason might that being a user requires an investment to buy a PC but not so much to subscribe to a cell phone company or internet. Eastern European countries do not have a diffusion speed as high as the other regions with respect to cell phones and internet, for the financial situation does not play a key role for these technologies. So spill-over effect from rich neighboring West European nations can only be seen for PC diffusion in East European nations. H1 is thus supported partly as regions have similarities (most of them are developing) as well as differences (physical distances, economic conditions etc.) when compared with the rest of the regions for different ICTs.
As regards to hypothesis H2a, it is not supported for diffusion of any of the selected technologies. The reason might be that autocratic and communist governments have control over the public moneys to promote diffusion of technology via government investments, and they can push strongly or stop completely the diffusion, but it can be either one of the two choices, therefore, the type of government can't be correlated to the diffusion of technology if we do not consider other factors driving the governments to support diffusion. H2b is supported as various pillars of governance do affect diffusion speed of these nations. Government effectiveness, rule of law as well as a lack of each of regulation and corruption control mechanisms also aid in augmenting the speed of diffusion. Further research is needed for analyzing the results of H2b.

CONCLUSION

This study analyzed the data provided by lagging countries on the implementation of ICT, which might not be representative of the innovators who first adopted such technologies. The sample of selected countries might not be representative of the neighboring countries, so the model can't be fully validated; also we need to be careful about the results as classification of nations may not be perfect. In spite of these deficiencies the study contributes in several ways. First, it is a study of three sets of mostly developing nations and the results showed ICT diffusion speeds differ in these nations in a number of ways. Secondly a clustering based on physical proximity yielded significant results for different clusters and different ICTs. Third, nations classified on different government regimes did not yield meaningful results; however, governance mechanisms including regulatory variables play a role on diffusion speeds of developing nations.

We can recommend lagging countries to pay attention to certain aspects such as use of prepaid mobile phone cards as a way to further diffuse this technology within the country; for internet users compared with computer owners there is an important gap that is even wider in Central America and Caribbean because of the existence of internet cafes. People, who cannot afford to buy a computer, can go to browse the Internet at these sites and as they gain skill, they might become future buyers.

Future studies of more countries and comparison with developed economies could provide a perspective of a generalized model for future validation.

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